DECLARATION OF DR. RICHARD CRAWFORD

I. BACKGROUND INFORMATION

A. Summary of My Professional Background and Qualifications

1. My professional background and qualifications are set forth in my Curriculum Vitae, a copy of which is attached as Exhibit 1.

2. I am currently a Professor of Mechanical Engineering at The University of Texas at Austin, Cockrell School of Engineering. I am an Earl N. & Margaret Brasfield Endowed Faculty Fellow. I hold a B.S. degree in Mechanical Engineering from Louisiana State University, and M.S. and Ph.D. degrees in Mechanical Engineering from Purdue University. I have been teaching at the University of Texas at Austin since January 1990. In 1989 I cofounded the Manufacturing and Design Research Laboratory ("MADLab") at the University. The MADLab focuses on developing concepts, tools, and techniques for innovative product design and manufacturing. I also co-founded the Design Technology and Engineering for America's Children (DTEACh) program that focuses on improving science and mathematics education in the elementary grades by providing hands-on experiences with technology. In addition, I am one of two faculty in the Cockrell School of Engineering that have partnered with UTeach (a highly acclaimed program at the University to prepare pre-service secondary science, math, and computer science teachers) to develop an engineering track for UTeach called UTeachEngineering. I also directed the Texas Energy Science Symposiums from 1996-2001, and from 1998-2001 I participated as a co-instructor at the Engineering Design Institute sponsored by the UT Office of the Vice President for Administration and Public Affairs.

3. During my time at the University of Texas at Austin, I have received various awards and honors, including: Red Apple Award (Austin Independent School District, 1992);

American Society for Engineering Education Fred Merrifield Design Award (1995); Best Paper Award (ASME Design Theory and Methodology Conference, 1999); Halliburton/Brown & Root Faculty Excellence Award (2000); Excellence in Education Award (Engineering, Science and Technology Council of Houston, 2001); Maxine and Jack Zarro Family K-16 Teaching Innovation Award (2004); Lockheed Martin Aeronautics Company Excellence in Engineering Teaching Award (2005); Ralph Coats Roe Award (American Society for Engineering Education (2010); The University of Texas System Regents' Outstanding Teaching Award (2011).

4. In addition to being a fellow of the American Society of Mechanical Engineers, I am also an active member in the following professional and honorary societies: American Society for Engineering Education; Association for Computing Machinery; Society of Automotive Engineers; Society of Manufacturing Engineers; Phi Kappa Phi; Pi Tau Sigma, Order of the Engineer and Tau Beta Pi. I am also a licensed Professional Engineer in the State of Texas (PE Number 88062).

5. My research focuses on the development of computational tools and methods for engineering design and manufacturing. I am actively involved in Additive Manufacturing (AM) research in the areas of geometric evaluation and design tools for applications of the selective laser sintering and 3D printing processes. Another aspect of my research involves development of a new approach to geometric modeling that is appropriate for the earlier, conceptual stages of engineering design. In addition, I also conduct research on the performance of polymer seals.

6. I have over 25 years of experience in engineering design, including practical experience in advising my masters and Ph.D. students on research projects, relating to engineering design theory and methodology, additive manufacturing and geometric modeling. I

have published approximately 37 technical journal papers, and have authored over 80 refereed conference proceedings on various topics relating to mechanical engineering and design.

7. I am a named inventor (with co-inventors) on 9 patent documents, including patent applications. My Curriculum Vitae, attached as Exhibit 1, lists all publications that I have authored or co-authored in the previous 10 years, as well as those patents on which I am a named inventor.

8. I have testified as an expert either at trial or by deposition on 2 occasions during the previous four years.

9. I am being compensated $200 hour per hour for my time spent in connection with this case. No part of my compensation depends on the outcome of this litigation or the nature of the opinions that I express.

10. I understand that Pisony may present witnesses who may be submitting written and/or oral testimony as part of the claim construction process. I reserve the right to respond to any such testimony and to supplement my opinions in view of such testimony.

B. Scope of this Report

11. I have been asked to evaluate certain claim terms of U.S. Patent Number 7,591,629, and to offer my opinions on the meaning of these claim terms, which include:

- "the conveyor assembly includes … *an extendible mast*"; and
- "the mast includes a hydraulic cylinder drivable to telescope to various lengths."

C. Information Considered in Forming My Opinions

12. In forming my opinions, I have reviewed and considered at least the following information:

- U.S. Patent Number 7,591,629 ("the '629 Patent");

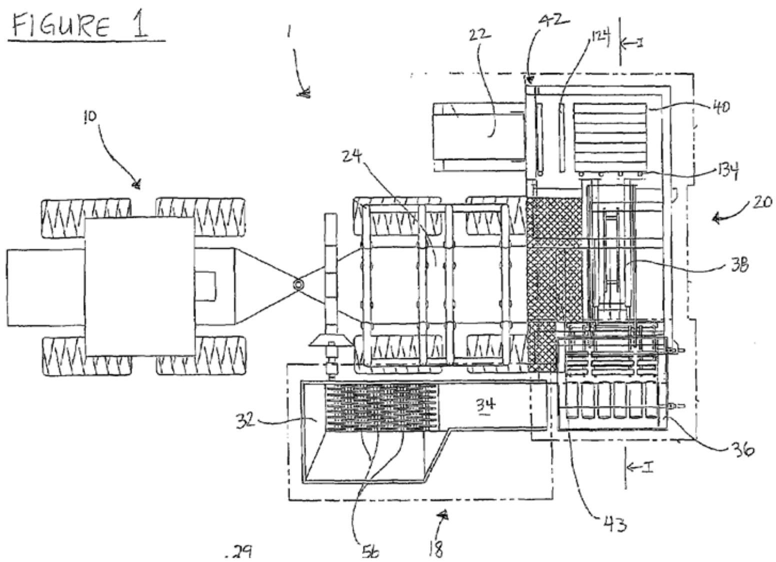
- The file history for the '629 Patent;
- The file history for U.S. Patent Application No. 12/539790;
- CCI's Preliminary Claim Constructions;
- Pisony's Proposed Constructions;
- Canadian Patent No. 2,315,046;
- U.S. Patent No. 5,934,861;
- U.S. Patent No. 7,320, 202;
- Exhibits A-E to CCI's Preliminary Invalidity Contentions;
- Excerpts from the following Dictionaries:
    - Merriam-Webster Dictionary (mast) (CCI0008895-8897);
    - Webster's New World College Dictionary (mast) (CCI0009025-9027);
    - The American Heritage Dictionary (mast) (CCI0009081-9083);
    - Webster's New College Dictionary (mast) (CCI0008982-8984);
    - Webster's Unabridged Dictionary (mast) (CCI0009066-9068);
    - Illustrated Oxford Dictionary (mast) (CCI0008819-8821);
    - Dictionary of Construction, Surveying and Civil Engineering (mast) (CCI0008909-8912);
    - Oxford Dictionary of English (mast) (CCI0008918) ;
    - McGraw-Hill Dictionary of Scientific and Technical Terms (mast) (CCI0008919-8921);
    - The MacMillan Visual Dictionary (mast) (CCI0008834-8854);
    - Dictionary of Mechanical Engineering (CCI0008861-8868).

II. ASSERTED PATENT

13. I understand that this lawsuit involves the ‘629 Patent, titled “All Terrain Lumber Collection and Stacking Apparatus.” I will refer to this as the Pisony Patent.

14. The machine described in the Pisony Patent relates to a propelled device to pick up, sort, stack, bundle and off-load lumber pieces, referred to by the applicant as “skids.” Below is Figure 1 (annotated) from the Pisony Patent that shows a top plan view of an example of the disclosed all-terrain apparatus and its various major components – specifically the conveyor assembly and the stacking assembly.

FIGURE 1

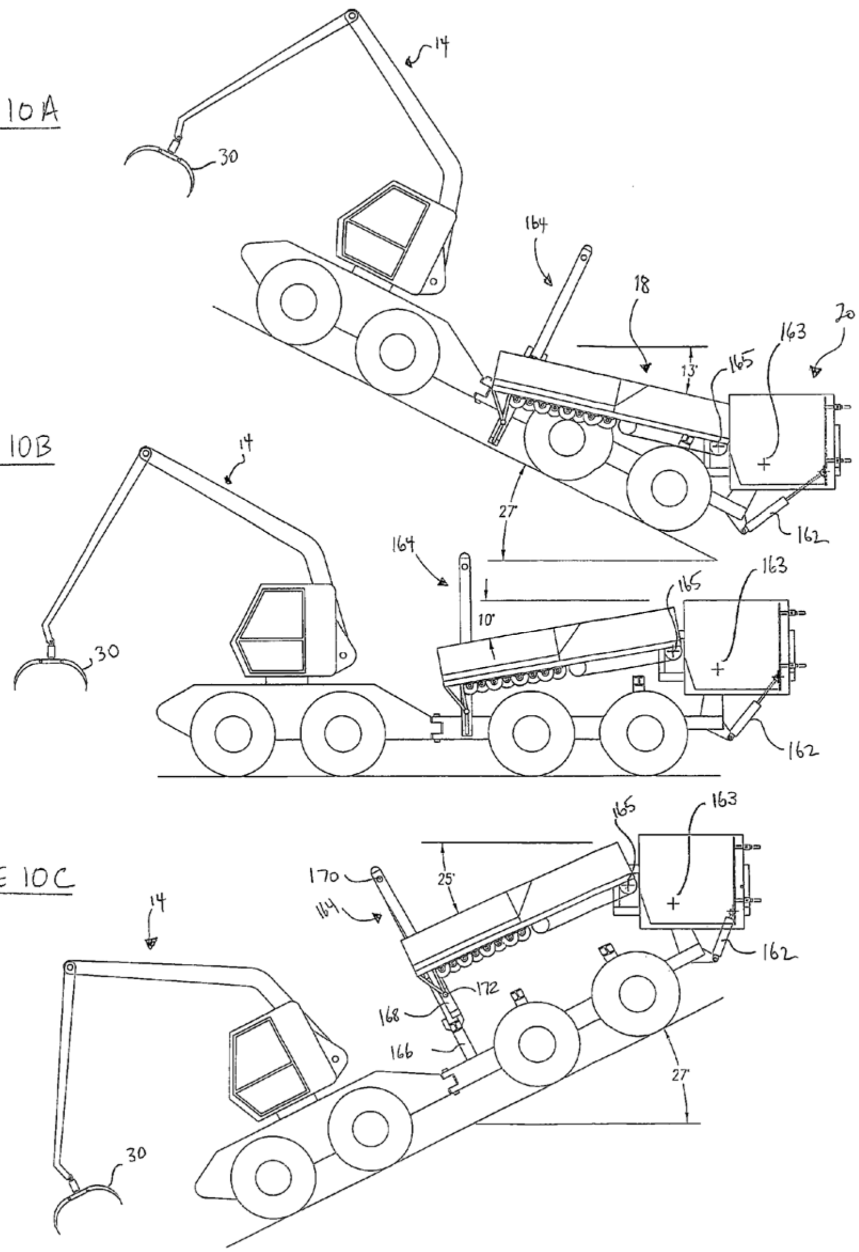


15. The all-terrain apparatus shown uses simple and fairly standard components to accomplish its intended purposes. When the apparatus is faced with varying and uneven terrain, it is desired that the stacking assembly (20) remain relatively level, that is horizontal, as illustrated in Figs. 10A-C shown below.

FIGURE 10A

FIGURE 10B

FIGURE 10C



16. The applicant also advises of the need to keep the conveyor assembly properly oriented in relation to the stacking assembly when it moves so that it will efficiently deposit lumber into the unscrambling hopper (a component of the stacking assembly). The conveyor assembly is moved by what the applicant calls a "mast assembly," which, as shown in Figs. 10A-

C above, works to raise and lower the conveyor assembly to accommodate for the slope of land on which the apparatus is used.

17. To achieve its desired orientation relative to the stacking assembly, the conveyor assembly is moved up or down along the "mast assembly." The "mast assembly" can be extended (increased in length) by using a hydraulic cylinder, telescoping the "mast assembly" vertically, and thereby moving the conveyor assembly upwardly.

III. LEGAL STANDARDS

18. I understand that claim construction begins with the language of the claims. I understand that the claims are read in the context of the entire patent, including the specification. I have been informed that the specification is the single best guide to the meaning of a disputed term. Accordingly, I understand that the specification is highly relevant to the claim construction analysis.

19. I have also been informed that the prosecution history of an issued patent is also relevant to claim construction. I understand that the prosecution history can provide evidence about how the patent office and the inventors understood the patent.

20. I have also been informed that, unless otherwise indicated by the patent's specification or prosecution history, claim terms should be given the plain and ordinary meaning that would generally be understood by a person of ordinary skill in the art.

21. I understand that a person of ordinary skill in the art is one who is presumed to have the skill and experience of an ordinary worker in the field and is deemed to have knowledge of all pertinent art at the time of the invention. I further understand that a person of ordinary skill in the art is one who thinks along the lines of conventional wisdom in the art.

22. I have been informed that the level of ordinary skill in the art for a particular patent may be based on various factors, including the following: (1) the types of problems commonly encountered in the art; (2) the types of solutions that have been developed to address those problems; (3) the pace and frequency of innovation in the field; (4) the sophistication of the technology; and (5) the educational level of active workers in the field. I have also been informed that in a given case, every factor may not be present, and one or more factors may predominate.

23. I have been further informed that extrinsic evidence, such as expert testimony, dictionaries, and other patents can be considered by a court if helpful to understand the field of the invention and to determine what a person of ordinary skill in the art would understand the claim terms to mean. I have also been informed that extrinsic evidence must be considered in the context of the intrinsic evidence.

IV. PERSON HAVING ORDINARY SKILL IN THE ART

24. In forming my opinions, I have used a person having ordinary skill in the art as someone who has a four-year degree in a technical field such as mechanical engineering or like discipline, and approximately 2 years of experience in the design and development of mechanical structures or devices. In the absence of a degree in a technical field such as mechanical engineering, a person having ordinary skill in the art would have at least 5 years of experience in the design and development of mechanical structures or devices.

V. PATENT CLAIM TERMS

D. "the conveyor assembly includes … *an extendible mast*"

25. This term appears in claim 1 of the Pisony patent. The term "extendible mast" does not appear anywhere in the specification of the '629 patent.

26. I understand that CCI proposes the term “extendible mast” mean “a vertical pole or similar structure that may increase in length.” I have been informed that Pisony proposes this term means “a structural support member capable of raising and lowering.”

27. CCI’s proposed construction is not only how a person of ordinary skill in the art would understand this term, it is also supported by the specification. Specifically, a “mast” is commonly understood in mechanical engineering to mean a vertical pole-like structure, which is consistent with the description in the specification. Further, the ordinary meaning of “extendible,” i.e., increasing or changing in length, is also consistent with the specification.

28. The phrase “mast” is a commonly used term with a well-established technical meaning to those of ordinary skill in the field of mechanical engineering.

29. A person of ordinary skill would understand the term “mast” to refer to a vertical pole or similar structure, which may also serve as a support structure.

30. While the term “mast” is most commonly used to refer to the vertical members to carry sails on ships or poles that support antennas, it is also commonly understood to mean any type of vertical pole-like structure.

31. I am unaware of any use of the term “mast” to refer to a horizontally-oriented, elongate structure. In the relevant field, a “beam” or a “boom” is used to refer to an elongate horizontal structure. A “mast” may pivot to perform its intended function (i.e., to lower a load), and it does not have to be at a precisely 90 degree angle to the horizontal plane, to still be considered a “mast.” However, a “mast” is understood by those in the field to be a generally vertical structure.

32. The term “extendible” as used in the phrase “extendible mast,” modifies the term “mast.” Therefore, the phrase “extendible mast” would be understood by a person of ordinary

skill in the art to be a vertical pole-like structure that can vary or increase in length or height. In other words, a mast that is "extendible" means the distance between the proximal and distal ends of the mast may be increased.

33. The specification of the '629 patent is consistent with the plain and ordinary meaning of the term "extendible mast." The term "extendible mast" appears nowhere in the specification.

34. A "mast assembly" is described in the specification of the '629 patent as follows:

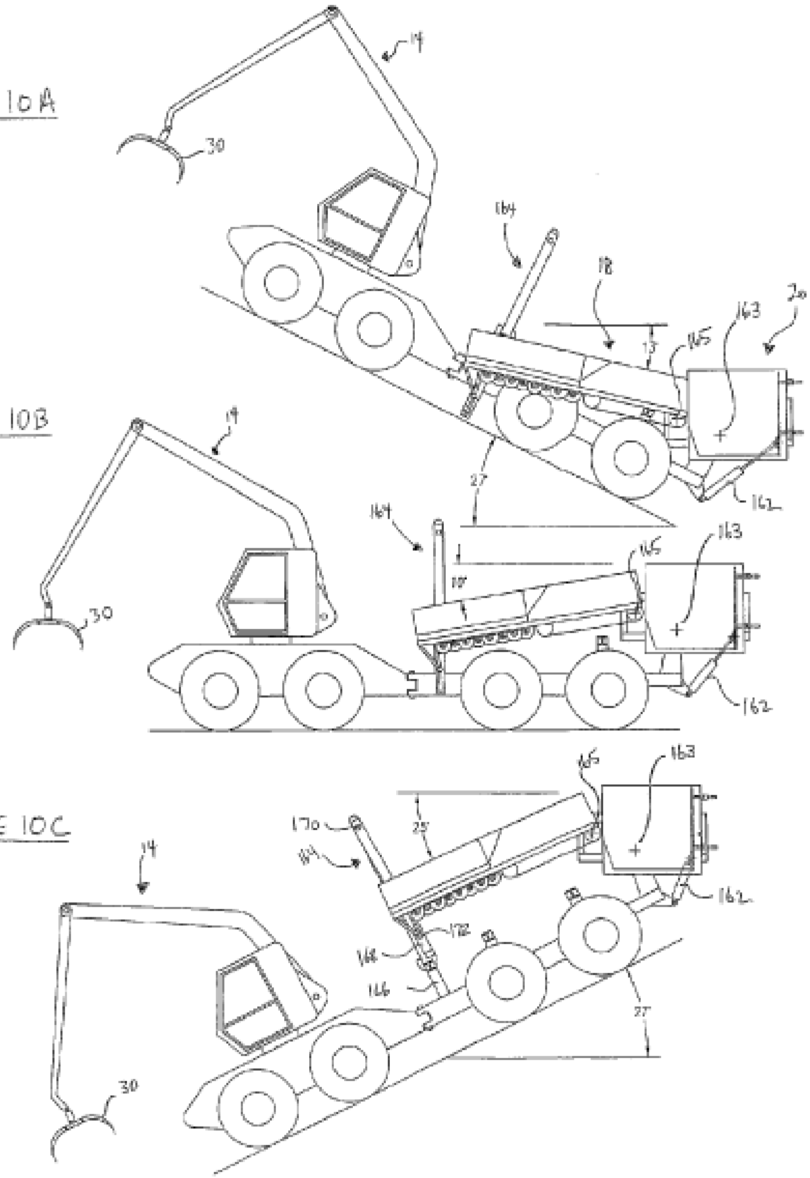
> The apparatus may also comprise a mast assembly **164**, to raise and lower the conveyor assembly **18**, to accommodate for the slope of the land on which the apparatus is being used. Therefore, conveyor assembly **18** may be moved up or down along mast assembly **14**, which may comprise an inner mast **166** and an outer mast **158**, each of which may comprise a hydraulic cylinder disposed therein to provide means of moving the mast vertically. FIGS. 11A and B shows the position of outer mast **168** and inner mast **166** at three different positions or heights, A, B and C, of conveyor assembly **18**, corresponding to FIG. 10C, FIG. 10B and FIG. 10A, respectively.

'629 patent, Col. 10, ll. 43-54.

FIGURE 10A

FIGURE 10B

FIGURE 10C

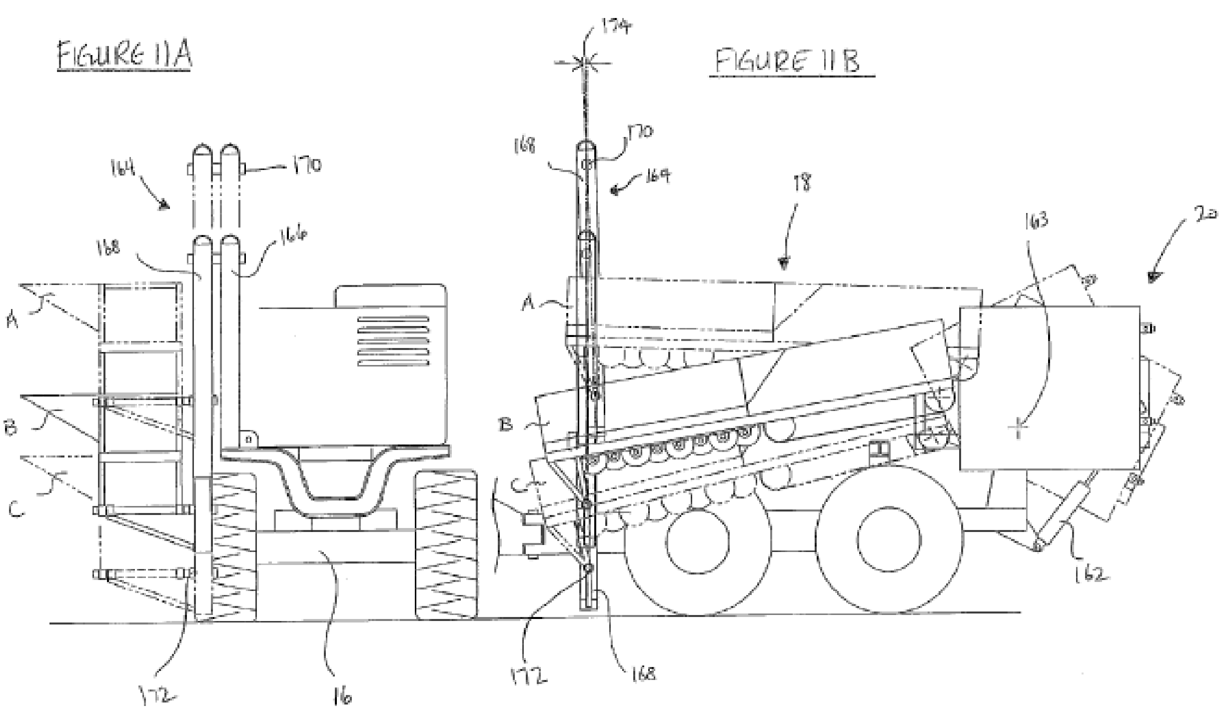


35. The "mast assembly" described in the specification is a vertical pole-like structure that can increase in length along its vertical axis. The specification describes the "conveyor assembly 18 may be *moved up or down along* mast assembly"; the inner and outer masts "may comprise a hydraulic cylinder disposed therein to provide means of moving the mast *vertically*"; "FIGS. 11A and B shows the position of outer mast 168 and inner mast 166 at three different

positions or *heights*, A, B and C, of conveyor assembly 18, corresponding to FIG. 10C, FIG. 10B and FIG. 10A, respectively." Another portion of the specification describes the '[i]nner mast 166 may be *mounted relatively perpendicular* to the chassis of the trailer 16, as shown in FIG. 11A," "[c]onveyor assembly 18 may be attached to outer mast 168 at pivot point 172, and *moves up and down with outer mast 168*," and "[i]nner mast 166 telescopes *upwardly* to achieve positon A in FIG. 10C." '629 patent, Col. 10, ll. 60-61.

36. Because the word "extendible" does not appear anywhere in the specification, the only meaning that can be given to this term is that which is described above. Namely, the height of the mast may increase, which may be achieved by using a hydraulic cylinder to move the mast vertically or by "telescoping" the mast upwardly.

37. Figures 11A and 11B, in addition to figures 10A-10C, clearly illustrate the "extendible mast" moving vertically to raise the conveyor frame to "three different positions or heights, A, B, and C":



SLC-8658786-2

38. I have also reviewed the prosecution history of the '629 patent, which supports CCI's proposed construction of "extendible mast." The Patent Office rejected dependent claims directed to "a means of raising and lowering the conveyor assembly" and "a mast assembly for raising and lowering the conveyor assembly" in view of Canadian Patent 2,315,046 to McLeod ("McLeod"), which, in addition to most of the other limitations of the claims, disclosed a means for raising the conveyor assembly.

39. Additionally, I have reviewed the prosecution history of U.S. Patent Application No. 12/539790, a continuation of the '629 patent. Similar to the '629 patent, the Patent Office rejected claims directed to "a mast assembly for raising and lowering the conveyor assembly" in view of McLeod and U.S. Patent No. 3,651,963 to McWilliams, which expressly teaches a mast assembly for raising and lowering a conveyor assembly.

40. "A mast assembly for raising and lowering the conveyor frame" is *narrower* than Pisony's proposed construction of "a structural support member capable of raising and lowering," because it is at least limited to a "mast assembly" rather than any kind of "structural support member."

41. Pisony's proposed construction is also not consistent with how a person of ordinary skill in the art would ordinarily understand the term "extendible mast," as discussed above. It ignores both the plain and ordinary meaning of the terms "extendible" and "mast," and the teaching of the '629 patent.

42. Under Pisony's proposed construction, the mast need not be a vertical structure, nor be capable of increasing in length or height. Instead, Pisony's proposed construction would encompass a potentially infinite number of "structural support members" capable of raising and lowering something else, including those described in the prior art. For example, the Patent

Office found that McLeod discloses a "means for raising and lower the conveyor assembly," and McWilliams discloses a "mast assembly for raising and lowering the conveyor assembly." U.S. Patent No. 5,934,861 also expressly teaches a hydraulic cylinder connected between a frame and a conveyor to actuate "upward and downward vertical movement 29 of the forward end 27 of the conveyor table."

43. Additionally, "raising and lowering" is already accounted for in the remainder of claim 1 of the '629 patent. For example, the "extendible mast connected between the frame and the chassis *to drive the frame about the pivotal connection*," and "the mast being operable to *drive adjustment of the angle of the frame relative to the chassis,"* means the "extendible mast" necessarily raises and lowers the conveyor frame.

E. "the mast includes a hydraulic cylinder"

44. This term appears in dependent claim 6 of the '629 patent, which is a dependent upon claim 1. As such, I understand that this claim must have, at minimum, all of the limitations of claim 1. Although the term as found in claim 6 only refers to "mast," that "mast" must be an "extendible mast" as required by claim 1. This provides context to the remaining words used in this term and their function with one another.

45. CCI proposes that this term means "a hydraulic cylinder within the extendible mast to vary in length in a telescoping manner (i.e., overlapping sections in and out from one another)." Pisony, on the other hand, proposes that the term does not need to be construed, and that it be given its plain and ordinary meaning. Alternatively, Pisony contends the term means "mast incorporates a hydraulic cylinder drivable to telescope to various lengths."

Col. 10, lines 20-67 (emphasis added).

46. CCI's proposed construction is supported by the specification. For example, the only discussion of a hydraulic cylinder in the specification states:

> Therefore, conveyor assembly **18** may be moved up or down along the mast assembly **164**, which may comprise an inner mast **166** and an outer mast **168**, each of which may comprise a hydraulic cylinder disposed therein to provide means of moving the mast vertically.

Col. 10, lines 46-50.

47. The written description is otherwise silent on the use of a hydraulic cylinder in or in conjunction with the "mast assembly" or any of its potential component parts. Similarly, the drawings of the '629 patent do not specially identify any such hydraulic cylinder.

48. However, hydraulic cylinders well known mechanical devices that generally consist of slidably connected piston and cylinder members. As fluid is forced into the device, usually under pressure, the piston slides relative to the cylinder, causing the distal ends of these members to extend away from one another and the combined device grows in length. That is, the piston and cylinder of the hydraulic cylinder telescope apart. As fluid is then released from the device, the distal ends of the piston and cylinder retract towards one another, and the device shortens in length. Hydraulic cylinders, therefore, inherently "telescope."

49. As provided in claim 6, and in view of the specification, this would encompass a hydraulic cylinder disposed within the distal end of a fixed length mast, and, as the hydraulic cylinder telescopes, the "mast" extends or grows in its overall vertical length, as the hydraulic cylinder would be considered a part of the "extendible mast."

50. Similarly, while not specifically described in the specification, this reading could encompass a hydraulic cylinder disposed inside nested and telescoping pole-like segments making up the "extendible mast." As the hydraulic cylinder is put into action, it pushes one of

those nested mast segments along their vertical axis, driving the nested segments apart length-wise, thereby telescoping the mast in a vertical direction, extending or increasing its length.

51. Under either reading, as the hydraulic cylinder increases its length along its longitudinal axis, the mast extends along its longitudinal axis. In other words, the mast itself telescopes in length, and the hydraulic cylinder acts as the means of varying the length of the extendible mast.

Date: 7/19/18

Richard H Crawford

Dr. Richard H. Crawford, Ph.D., P.E.

Exhibit 1 to Crawford Declaration

THE UNIVERSITY OF TEXAS AT AUSTIN
Cockrell School of Engineering
Resume

FULL NAME: Richard H. Crawford **TITLE:** Professor

ENDOWMENT: Earl N. & Margaret Brasfield Endowed Faculty Fellow

DEPARTMENT: Mechanical Engineering

DATE OF BIRTH: August 12, 1954

CITIZENSHIP: USA

SPOUSE'S NAME: Dianne M. Crawford

EDUCATION:	BSME	Louisiana State University	May 1982
	MSME	Purdue University	December 1985
	Ph.D.	Purdue University	December 1989

PROFESSIONAL REGISTRATION: Texas Serial Number 88062

CURRENT AND PREVIOUS ACADEMIC POSITIONS:

The University of Texas at Austin, Professor of Mechanical Engineering, September 2002-present.

The University of Texas at Austin, Associate Professor of Mechanical Engineering, September 1995-August 2002.

The University of Texas at Austin, Assistant Professor of Mechanical Engineering, January 1990-August 1995.

Purdue University, Graduate Teaching Assistant, January 1984-May 1989.

Purdue University, Graduate Research Assistant, January 1983-December 1989.

OTHER PROFESSIONAL EXPERIENCE:

Distributed Visualization Systems Group, Sandia National Laboratory, Livermore, CA, Faculty Intern, June 2003-August 2003.

Electronic Card Assembly and Test, IBM, Austin, TX, Faculty Intern in Manufacturing Engineering, September 1992-August 1993.

Ford Motor Company, Alpha Manufacturing Development Center, Detroit, MI, Faculty Intern, June 1992-August 1992.

Ford Motor Company, Scientific Research Laboratories, Dearborn, MI, Faculty Intern, June 1991-August 1991.

Louisiana State University, Department of Petroleum Engineering, Research Associate, June 1982-December 1982.

Master Maintenance, Inc., Baton Rouge, LA, Heating and Air Conditioning Mechanic, August 1977-September 1979.

East Baton Rouge Parish School Board, Baton Rouge, LA, Heating and Air Conditioning Mechanic, July 1974-July 1977.

Menzie Tile Company, Baton Rouge, LA, Tile Setter's Helper, January 1973-June 1974.

HONORS AND AWARDS:
R. C. Baker Foundation Scholarship, Louisiana State University, 1982
Outstanding Mechanical Engineering Undergraduate, Louisiana State University, Spring 1982
Purdue University Fellow, Purdue University, 1983
Shell Foundation Fellow, Purdue University, 1984-85
Standard Oil of Ohio Fellow, Purdue University, 1986
General Electric Foundation Forgivable Loan Recipient, Purdue University, 1986 & 1989
Society of Automotive Engineers Forgivable Loan Recipient, Purdue University, 1987-88 & 1988-89
Red Apple Award, Austin Independent School District, 1992
American Society for Engineering Education Fred Merryfield Design Award, 1995
Best Paper Award, 1999 ASME Design Theory and Methodology Conference, 1999
Halliburton/Brown & Root Faculty Excellence Award, 2000
Excellence in Education Award, Engineering, Science and Technology Council of Houston, 2001
Maxine and Jack Zarrow Family K-16 Teaching Innovation Award, 2004.
Lockheed Martin Aeronautics Company Excellence in Engineering Teaching Award, 2005.
Ralph Coats Roe Award, American Society for Engineering Education, 2010.
The University of Texas System Regents' Outstanding Teaching Award, 2011.

MEMBERSHIPS IN PROFESSIONAL AND HONORARY SOCIETIES:
Fellow, American Society of Mechanical Engineers.
Member, American Society for Engineering Education.
Member, Association for Computing Machinery.
Member, Society of Automotive Engineers.
Member, Society of Manufacturing Engineers.
Member, Phi Kappa Phi.
Member, Pi Tau Sigma.
Member, Order of the Engineer.
Member, Tau Beta Pi.

PUBLICATIONS:

Refereed Archival Journals

1. Rogers, B., Bosker, G. W., Crawford, R. H, Faustini, M. C., Neptune, R. R., Walden, G., and Gitter, A. J., "Advanced Trans-Tibial Socket Fabrication Using Selective Laser Sintering," *Prosthetics and Orthotics International*, vol. 31, no. 1, pp. 88 – 100, 2007.

2. Turner, C. J., Campbell, M. I., and, Crawford, R. H., "Multidimensional Sequential Sampling for Metamodel Development", *Engineering with Computers*, vol 23, no. 3, pp. 155-174, 2007.

3. Turner, C. J., Crawford, R. H., and Campbell, M. I., "Global Optimization of NURBS-Based Metamodels," *Engineering Optimization*, vol. 39, no. 3, pp. 245-269, 2007.

4. Faustini, M. C., Neptune, R. R., Crawford, R. H., and Stanhope, S. J., "Manufacture of Passive Dynamic Ankle-Foot Orthoses Using Selective Laser Sintering," *IEEE Transactions on Biomedical Engineering*, vol. 55, no. 2, pp. 784-790, 2008.

5. Rogers, B., Bosker, G., Faustini, M., Walden, G., Neptune, R. R., and Crawford, R. H., "Case Report: Variably Compliant Transtibial Prosthetic Socket Fabricated Using Solid Freeform Fabrication," *Journal of Prosthetics and Orthotics*, vol. 20, no. 1, pp. 1-7, 2008.

6. Turner, C. J., and Crawford, R. H., "N-Dimensional Non Uniform Rational B-splines for Metamodeling," *Journal of Computing and Information Science in Engineering*, vol. 9, no. 3, pp. 031002 (13 pages), 2009.

7. Montgomery, J. T., Vaughan, M. R., and Crawford, R. H., "Design of an Actively Actuated Prosthetic Socket," *Rapid Prototyping Journal*, vol. 16, no. 3, pp. 194-201, 2010.

8. Weaver, J., Wood, K., Crawford, R., and Jensen, D., "Transformation Design Theory: A Meta-Analogical Framework," *Journal of Computing and Information Science in Engineering*, vol. 10, no. 3, pp. 031012 (11 pages), 2010.

9. Vaughan, M. R., and Crawford, R. H., "Effectiveness of Virtual Models in Design for Additive Manufacturing: A Laser Sintering Case Study," *Rapid Prototyping Journal*, vol. 19, no. 1, pp. 11-19, 2013.

10. Steuben, J., Turner, C., and Crawford, R., "Robust Engineering Design Optimization with NURBs-Based Metamodels," *Engineering Optimization*, vol. 45, no. 7, pp. 767-786, 2013.

11. Camburn, B., Otto, K., Jensen, D., Crawford, R., Wood, K., "Designing Biologically Inspired Leaf Structures: Computational Geometric Transport Analysis of Volume-To-Point Flow Channels," *Engineering with Computers*, vol. 31, no. 2, pp 361-374, 2014.

12. Blanchard, S., Judy, J., Muller, C., Crawford, R. H., Petrosino, A. J., White, C. K., Lin, F.-A., and Wood, K. L., "Beyond Blackboards: Engaging Underserved Middle School Students in Engineering," *Journal of Pre-College Engineering Education Research (J-PEER)*, vol. 5, no. 1, article 2, 2015, 14 pages.

13. Camburn, B., Dunlap, B., Gurjar, T., Hamon, C., Green, M., Jensen, D., Crawford, R., Otto, K., and Wood, K., "A Systematic Method for Design Prototyping," *Journal of Mechanical Design*, vol. 137, no. 8, 081102, 2015, 12 pages.

14. Camburn, B., Viswanathan, V. Linsey, J., Anderson, D., Jensen, D., Crawford, R., Otto, K., and Wood, K., "Design Prototyping Methods: State-of-the-Art in Techniques, Strategies, and Heuristics," *Design Science*, in press (published online August 3, 2017, https://doi.org/10.1017/dsj.2017.10).

Refereed Conference Proceedings

1. Turner, C. J., Crawford, R. H., and Campbell, M. I., "Mixed Integer Optimization with NURBS HyperModels," *Proceedings of the 27th ASME Computers and Information in Engineering Conference*, Las Vegas, NV, September 4-7, 2007.

2. Ma, G., and Crawford, R. H., "Identifying the Critical Points of Skeleton-Based Convolution Surfaces for Conceptual Design," *Proceedings of the 27th ASME Computers and Information in Engineering Conference*, Las Vegas, NV, September 4-7, 2007.

3. Talley, A. B., Schmidt, K. J., Crawford, R. H., and Wood, K. L., "Understanding the Effects of Active Learning in Action: What Happens When the "New" Wears Off in Teacher Training," *Proceedings of the 2008 ASEE Annual Conference and Exposition*, Pittsburgh, PA, June 22-25, 2008.

4. Ajetunmobi, A. M., Turner, C. J., and Crawford, R. H., "Robust Optimization with NURBS HyperModels," *Proceedings of the 28th ASME 2008 Computers and Information in Engineering Conference*, New York, NY, August 2-6, 2008.

5. Ma, G., and Crawford, R. H., "Topological Consistency in Skeletal Modeling with Convolution Surfaces," *Proceedings of the 28th ASME 2008 Computers and Information in Engineering Conference*, New York, NY, August 2-6, 2008.

6. Talley, A. B., and Crawford, R. H., "Creating LEGO Prototypes for K-5 Using Functional Modeling," *Proceedings of the 2009 ASEE Annual Conference and Exposition*, Austin, TX, June 14-17, 2009.

7. Talley, A., White, C., Wood, K., and Crawford, R., "Designing Interdisciplinary Curriculum and Teaching: Investigating Innovation in our Engineered World," *Proceedings of the 2010 ASEE Annual Conference and Exposition*, Louisville, KY, June 20-23, 2010.

8. White, C., Talley, A., Jensen, D., Wood, K., Szmerekovsky, A., and Crawford, R., "From Brainstorming to C-Sketch to Principles of Historical Innovators: Ideation Techniques to Enhance Student Creativity," *Proceedings of the 2010 ASEE Annual Conference and Exposition*, Louisville, KY, June 20-23, 2010.

9. White, C., Crawford, R., Wood, K., and Talley, A., "Influences and Interests in Humanitarian Engineering," *Proceedings of the 2010 ASEE Annual Conference and Exposition*, Louisville, KY, June 20-23, 2010.

10. Weaver, J., Wood, K., Crawford, R., and Jensen, D., "Design of Energy Harvesting Technology: Feasibility For Low-Power Wireless Sensor Networks," *Proceedings of the 2010 ASME International Design Engineering Technical Conferences*, Montreal, Quebec, Canada, August 18-21, 2010.

11. Camburn, B., Wood, K., Jensen, D., Crawford, R., Wood, J., and Guillemette, J., "When to Transform? Development of Indicators for Design Context Evaluation," *Proceedings of the 2010 ASME International Design Engineering Technical Conferences*, Montreal, Quebec, Canada, August 18-21, 2010.

12. Kuhr, R., Wood, K., Jensen, D., and Crawford, R., "Concept Opportunity Diagrams and Constituent Relationship Charts: A Visual Modeling Method to Explore Multifunctional Design Concepts," *Proceedings of the 2010 ASME International Design Engineering Technical Conferences*, Montreal, Quebec, Canada, August 18-21, 2010.

13. Talley, A., Crawford, R. H., White, C., and Wood, K. L., "Longitudinal Evaluation of Project-Based Professional Development Institute: Mixed Method Assessment with MBTI Type Correlations," *Proceedings of the 2011 ASEE Annual Conference and Exposition*, Vancouver, B.C., Canada, June 26-29, 2011.

14. Talley, A., Crawford, R. H., and Talley, K., "Engineering Applicability of a Universal Design Performance, Measure," *Proceedings of the 2011 International Design Engineering Technical Conference & Computers and Information in Engineering Conference*, Washington, DC, August 28-21, 2011.

15. McEvoy, T., Dierks, E., Weaver, J., Inamdar, S, Zimowski, K., Wood, K, Crawford, R., and Jensen, D., "Developing Innovative Energy Harvesting Approaches for Infrastructure Health Monitoring Systems," *Proceedings of the 2011 International Design Engineering Technical Conference & Computers and Information in Engineering Conference*, Washington, DC, August 28-21, 2011.

16. Weaver, J., Wood, K., Crawford, R., and Jensen, D., "Exploring Innovation Opportunities in Energy Harvesting Using Functional Modeling Approaches," *Proceedings of the 2011 International Design Engineering Technical Conference & Computers and Information in Engineering Conference*, Washington, DC, August 28-21, 2011.

17. Krager, J., Wood, K., Crawford, R., Jensen, D., Cagan, J., Schunn, C., Linsey, J., White, C., "Understanding Innovation: A Study of Perspectives and Perceptions in Engineering," *Proceedings of the 2011 International Design Engineering Technical Conference & Computers and Information in Engineering Conference*, Washington, DC, August 28-21, 2011.

18. Inamdar, S., Zimowski, K., Crawford, R., Wood, K., and Jensen, D., "Nondestructive Methods of Integrating Energy Harvesting Systems for Highway Bridges," *Proceedings of 2012 SPIE Conference on Smart Structures and Materials & Nondestructive Evaluation and Health Monitoring*, San Diego, CA, March 10-14, 2012.

19. Brudigam, K. L., and Crawford, R. H., "Spatial Ability in High School Students," *Proceedings of the 2012 ASEE Annual Conference and Exposition*, San Antonio, TX, June 10-13, 2012.

20. Jensen, D. D., Wood, J. J., Knodel, P., Wood, K. L., Crawford, R. H., and Vincent, R., "Evaluating Ideation Using the Publications Popular Science, Popular Mechanics, and Make in Coordination with a New Patent Search Tool and the 6-3-5 Method," *Proceedings of the 2012 ASEE Annual Conference and Exposition*, San Antonio, TX, June 10-13, 2012.

21. Crawford, R. H., White, C. K., Muller, C. L., Petrosino, A. J., Talley, A. B., and Wood, K. L., "Foundations and Effectiveness of an Afterschool Engineering Program for Middle School Students," *Proceedings of the 2012 ASEE Annual Conference and Exposition*, San Antonio, TX, June 10-13, 2012.

22. Allen, D. T., Crawford, R. H., Berland, L. K., High, K. A., Petrosino, A. J., Dobbs, T. A., Farmer, C., and Marshall, J. A., "A Course Sequence in Engineering Design and Problem

Solving," *Proceedings of the 2012 ASEE Annual Conference and Exposition*, San Antonio, TX, June 10-13, 2012.

23. Christie, E. J., Jensen, D. D., Buckley, R. T., Menefee, D. A., Ziegler, K. K., Wood, K. L., and Crawford, R. H., "Prototyping Strategies: Literature Review and Identification of Critical Variables," *Proceedings of the 2012 ASEE Annual Conference and Exposition*, San Antonio, TX, June 10-13, 2012.

24. Berland, L. K., Allen, D. T., Crawford, R. H., Farmer, C., and Guerra, L., "Learning Sciences Guided High School Engineering Curriculum Development," *Proceedings of the 2012 ASEE Annual Conference and Exposition*, San Antonio, TX, June 10-13, 2012.

25. Farmer, C., Allen, D. T., Berland, L. K., Crawford, R. H., Guerra, L., "Engineer Your World: An Innovative Approach to Developing a High School Engineering Design Course," *Proceedings of the 2012 ASEE Annual Conference and Exposition*, San Antonio, TX, June 10-13, 2012.

26. Guerra, L., Allen, D. T., Crawford, R. H., and Farmer, C., "A Unique Approach to Characterizing the Engineering Design Process," *Proceedings of the 2012 ASEE Annual Conference and Exposition*, San Antonio, TX, June 10-13, 2012.

27. Inamdar, S., Zimowski, K., Gibbons, K. A., Rucker, B., Jensen, D. D., Wood, K. L., and Crawford, R. H., "Designing Novel Nondestructive Attachment Methods: A Methodology and Application to Energy Harvesting Systems," *Proceedings of the 2012 ASEE Annual Conference and Exposition*, San Antonio, TX, June 10-13, 2012.

28. Wood, K. L., Mohan, R. E., Kaijima, S., Dritsas, S., Frey, D. D., White, C. K., Jensen, D. D., Crawford, R. H., Moreno, D., and Pey, Kin-Leong, "A Symphony of Designiettes: Exploring the Boundaries of Design Thinking in Engineering Education," *Proceedings of the 2012 ASEE Annual Conference and Exposition*, San Antonio, TX, June 10-13, 2012.

29. Camburn, B., Wood, K., Crawford, R., and Jensen, D., "Novel Geometrical Approach to Designing Flow Channels," *Proceedings of the 2012 ASME International Design Engineering Technical Conference & Computers and Information in Engineering Conference*, Chicago, IL, August 12-15, 2012.

30. Camburn, B., Wood, K., Crawford, R., Robbens, J., Jensen, D., and Patil, A., "Advances in Transformational Design: Correlating Context Evaluation to Quality, Feasibility, and Novelty," *Proceedings of the 2012 International Design Engineering Technical Conference & Computers and Information in Engineering Conference*, Chicago, IL, August 12-15, 2012.

31. Talley, A. B., Crawford, R. H., and White, C. K., "Curriculum Exchange: Middle School Students Go Beyond Blackboards to Solve the Grand Challenges," *Proceedings of the 2013 ASEE Annual Conference and Exposition*, Atlanta, GA, June 23-26, 2013.

32. White, C. K., Crawford, R. H., Talley, A. B., Petrosino, A. J., and Bland, K., "Girls Go Beyond Blackboards towards Positive Attitudes about Engineering," *Proceedings of the 2013 ASEE Annual Conference and Exposition*, Atlanta, GA, June 23-26, 2013.

33. Vaughan, M. R., and Crawford, R. H., "Use of Concept Generation Techniques in Different Cultural Settings," *Proceedings of the 2013 ASEE Annual Conference and Exposition*, Atlanta, GA, June 23-26, 2013.

34. Camburn, B. A., Dunlap, B. U., Viswanathan, V. K., Linsey, J. S., Jensen, D. D., Crawford, R. H., Otto, K., and Wood, K. L., "Connecting Design Problem Characteristics to Prototyping Choices to Form a Prototyping Strategy," *Proceedings of the 2013 ASEE Annual Conference and Exposition*, Atlanta, GA, June 23-26, 2013.

35. Brown, A. O., Crawford, R. H., Jensen, D. D., Rencis, J. J., Liu, J., Watson, K. A., Jackson, K. S., Hackett, R. K., Schimpf, P. H., Chen, C-C., Orabi, I. I., Akasheh, F., Wood, J. J., Dunlap, B. U., and Sargent, E. R., "Assessment of Active Learning Modules: An Update of Research Findings," *Proceedings of the 2013 ASEE Annual Conference and Exposition*, Atlanta, GA, June 23-26, 2013.

36. Camburn, B. A., Dunlap, B. U., Kuhr, R., Viswanathan, V. K., Linsey, J. S., Jensen, D. D., Crawford, R. H., Otto, K., Wood, K. L., "Methods for Prototyping Strategies in Conceptual Phases of Design: Framework and Experimental Assessment," *Proceedings of the 2013 International Design Engineering Technical Conference & Computers and Information in Engineering Conference*, Portland, OR, August 4-7, 2013.

37. Seshagiri, N. K. and Crawford, R. H., "Computing Geometric Transformations of Irregular Teeth Sets for Orthodontic Treatment," *Proceedings of the 2013 International Design Engineering Technical Conference & Computers and Information in Engineering Conference*, Portland, OR, August 4-7, 2013.

38. Ma, G., and Crawford, R., "Conceptual Design by a Topology Consistency Skeletal Modeler with Convolution Surfaces," *Proceedings of the ASME 2013 International Mechanical Engineering Congress & Exposition*, San Diego, CA, November 15-21, 2013.

39. Hamon, C. L., Green, M. G., Dunlap, B., Camburn, B. A., Crawford, R. H., and Jensen, D. D., "Virtual or Physical Prototypes? Development and Testing of a Prototyping Planning Tool," *Proceedings of the 2014 ASEE Annual Conference and Exposition*, Indianapolis, IN, June 15-18, 2014.

40. Brown, A. O., Jensen, D. D., Crawford, R. H., Rencis, J. J., Sargent, E. R., Dunlap, B. U., Hackett, R. K., Jackson, K. S., Watson, K. A., Orabi, I. I., Liu, J., and Wood, J. J., "Active Learning Modules Assessments: An Update of Results by Gender and Ethnic Groups," *Proceedings of the 2014 ASEE Annual Conference and Exposition*, Indianapolis, IN, June 15-18, 2014.

41. Brown, A. O., Watson, K. A., Liu, J., Orabi, I. I., Rencis, J. J., Chen, C-C., Akasheh, F., Wood, J. J., Jackson, K. S., Hackett, R. K., Sargent, E. R., Dunlap, B. U., Wejmar, C. A., Crawford, R. H., and Jensen, D. D., "Assessment of Active Learning Modules: An Update on Research Findings," *Proceedings of the 2014 ASEE Annual Conference and Exposition*, Indianapolis, IN, June 15-18, 2014.

42. Marshall, K. S., Crawford, R., Green, M., and Jensen, D., “Analogy Seeded Mind-Maps: Testing of a New Design-By-Analogy Tool,” *Proceedings of the 2014 International Design Engineering Technical Conference & Computers and Information in Engineering Conference*, Buffalo, NY, August 17-20, 2014.

43. Vaughan, M. R., Seepersad, C. C., and Crawford, R. H., “Creation of Empathic Lead Users from Non-Users via Simulated Lead User Experiences,” *Proceedings of the 2014 International Design Engineering Technical Conference & Computers and Information in Engineering Conference*, Buffalo, NY, August 17-20, 2014.

44. Dunlap, B. U., Hamon, C. L., Camburn, B. A., Crawford, R. H., Jensen, D. D., Green, M. G., Otto, K., and Wood, K. L., “Heuristics-Based Prototyping Strategy Formation: Development and Testing of a New Prototyping Planning Tool,” *Proceedings of the ASME 2014 International Mechanical Engineering Congress & Exposition*, Montreal, Quebec, Canada, November 14-20, 2014.

45. Brown, A. O., Jensen, D. D., Schimpf, P. H., Crawford, R. H., Orabi, I. I., Watson, K. A., Liu, J., Jackson, K. S., Chen, C-C., Akasheh, F., Orr, M., Webster, K. L., Turvey, G., and Bhattacharyya, “Active Engineering Education Modules: A Summary of Recent Research Findings,” *Proceedings of the 2015 ASEE Annual Conference and Exposition*, Seattle, WA, June 14-17, 2015.

46. Marshall, K. S., Crawford, R. H., and Jensen, D. D., “Analogy Seeded Mind-Maps: A Simple and Quick Design-by-Analogy Method,” *Proceedings of the 2015 ASEE Annual Conference and Exposition*, Seattle, WA, June 14-17, 2015.

47. Gurjar, T., Crawford, R., Jensen, D., “Effects of a Structured Prototyping Strategy on Capstone Design Projects,” *Proceedings of the 2015 ASEE Annual Conference and Exposition*, Seattle, WA, June 14-17, 2015.

48. Camburn, B. A, Jensen, D., Crawford, R., Otto, K., and Wood, K., “Evaluation of a Strategic Method to Improve Prototype Performance with Reduced Cost and Fabrication Time,” *Proceedings of the 20th International Conference on Engineering Design (ICED 15)*, Milan, Italy, July 27-30, 2015.

49. Camburn, B., En Sng, K. H., Perez, K. B., Otto, K., Wood, K., Jensen, D., and Crawford, R., “The Way Makers Prototype: Principles of DIY Design,” *Proceedings of the 2015 International Design Engineering Technical Conference & Computers and Information in Engineering Conference*, Boston, MA, August 2-5, 2015.

50. Marshall, S., Crawford, R., and Jensen, D., “Analogy Seeded Mind-Maps: A Comparison of Verbal and Pictorial Representation of Analogies in the Concept Generation Process,” *Proceedings of the 2016 International Design Engineering Technical Conference & Computers and Information in Engineering Conference*, Charlotte, NC, August 21-24, 2016.

51. Chang, Y-C., and Crawford, R. H., “Design of a Desktop Wire-feed Prototyping Machine,” *2017 Annual Solid Freeform Fabrication Symposium Proceedings*, Austin, TX, August 7-9, 2017.

PATENTS:

1. "Method For Fabricating Artificial Bone Implant Green Parts," U.S. Patent 5,639,402, June 17, 1997.

2. "Mold Useful for Injection Molding of Plastics and Methods of Production and Uses Thereof," U.S. Patent 5,678,162, October 14, 1997.

3. "Artificial Bone Implants," U. S. Patent 6,183,515, February 6, 2001.

4. "Artificial Bone Implants," U. S. Patent 6,540,784, April 1, 2003.

5. "Rotary Plate Fastener for Ceiling Fan Blades," U. S. Patent 7,223,078, May 29, 2007.

6. "Modular Automated Assistive Guitar," U. S. Patent 7,285,709, October 23, 2007.

7. "Y-Connect Fastener for Ceiling Fan Blades," U. S. Patent 7,351,037, April 1, 2008.

8. "Radial Volume Adjustment Device," PCT Application Serial No. PCT/US2014/032015, March 27, 2014.

9. "Mechanisms for Constructing Spline Surfaces to Provide Inter-Surface Continuity," U.S. Patent Application No. 15433823, February 15, 2017.

EXPERT TESTIMONY AND DEPOSITIONS

YETI vs. RTIC claims construction deposition and hearing, 2016
YETI vs. RTIC expert report depositions, December 2016, January 2017